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Sensory Optimisation of Salt-Reduced Corned Beef for Different Consumer Segments

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Abstract

The study objectives were to determine assessors' (n=256) preference for corned beef, produced with sequential reductions in NaCl concentrations and to determine if preference was affected by assessor age. The use of a salt replacer such as potassium lactate was also assessed. The youngest age cohort disliked samples containing the highest level of NaCl, whereas the oldest age cohort did not detect differences between samples. The most negatively perceived sample was the control, suggesting that NaCl levels added to commercial corned beef are currently too high for consumer acceptance. All age cohorts, with the exception of the 65-74 age cohort, accepted corned beef samples possessing NaCl levels closest to the FSAI target (1.63g/100g). No major sensory differences were noted between samples with and without potassium lactate by the ≥65 age cohort. Potassium lactate may be added to corned beef without affecting sensory attributes, whilst enhancing nutritional content. Assessors of varying age groups have differing preferences for certain NaCl levels and salt replacers.

Keywords

Corned Beef, Potassium Lactate, Salt Reduction Programmes, Age

2. Introduction

Salt intake among adults in European Countries ranges from 7-13g per day (Kloss, Meyer, Graeve, & Vetter, 2015). In Ireland, 18-64 year olds have a mean daily intake of 7.4g salt, with men having higher intakes (8.5g) than women (6.2g). Adults aged 65 years and over have a mean daily salt intake of 6.3g, with men having higher intakes (7.3g) than women (5.4g) (IUNA, 2001). Evidence suggests that current levels of sodium consumption in Europe contributes to increased blood pressure in the population and consequently, the prevalence of cardiovascular (CVD) and renal diseases increase (EFSA, 2005). Currently the World Health Organisation (WHO) recommends that adults consume less than 5g of salt per day (WHO, 2010). It was estimated that if the average person would decrease salt intake by about 5g per day, a reduction of 23% of strokes and 17% incidences of CVD would result in preventing an estimated four million deaths annually worldwide (Strazzullo, D'Elia, Kandala, & Cappuccio, 2009). The main source of sodium in the diet is from processed foods (about 70-75% of the total intake) (EFSA, 2005). Salt reduction is a huge challenge for food manufacturers. Not only is taste effected as a consequence of salt reduction, this also impacts processors in their ability to successfully manufacture processed meat products via the extraction of myofibrillar proteins, in addition to achieving preservation requirements in order to maintain product safety and shelf-life (Desmond, 2006). Reductions in salt content in processed foods requires ingredients that do not negatively impact the sensory, safety or stability of the products in question. One salt reduction approach is food reformulation. Since the WHO initiated the Global Strategy on Diet, Physical Activity and Health to limit the levels of *trans* fatty acids, saturated fatty acids, sugar and salt in foods, many companies within the food and beverage sector have reformulated their products (WHO, 2007). The FSA (Food Safety Authority) started a campaign in 2003 to encourage a voluntary reduction of salt in processed foods. A mean salt reduction of 7% between 2006 and 2011 was observed in convenience foods resulting in a lower salt intake in the UK population. Since 2003, the Food Safety Authority of Ireland (FSAI) has coordinated a salt reduction programme working in partnership with the food industry, Food and Drink Industry Ireland (FDII), Retail Ireland, various State bodies and related organisations to achieve voluntary, gradual and sustained reductions in the salt content of processed foods. Through this initiative, they successfully reduced the level of salt in the following processed meat products: rashers by 27%, cooked ham by 15% and sausage products by 11% (FSAI, 2015).

Processed meats are one of the main sources of salt intake in our diets (Desmond, 2006). According to the IUNA (Irish Universities Nutrition Alliance) 47% of 18-64 year olds and 30% of the over 65 age cohort consume processed meat products (IUNA, 2011). This may be due to its high salt content which may appeal to those with declining sensory perception as the aging process occurs (Warwick & Schiffman, 1990). The FSA has recommended a salt reduction to 1.63g (650mg sodium) (Salt-Targets 2017, 2016) and the WHO has recommended a salt reduction level of 1.35g salt (540mg sodium) in corned beef (WHO, 2013). Corned beef was the food matrix chosen for this study. Corned beef is a traditional meat product commonly consumed by the Irish population, particularly senior citizens. According to Cliceri et al. (2017) familiarity with the product is the main factor affecting the consumption among senior citizens.

The use of potassium-based ingredients for salt replacement by the food industry could help supplement intakes of potassium and reduce the intake of sodium by the Irish population (FSAI 2009). However, the FSAI has raised concerns about the health effects of increasing potassium in the diets of sub-groups of the population with Type 1 diabetes, chronic renal insufficiency, end-stage renal disease, severe heart failure and adrenal insufficiency (FSAI, 2015). However, US dietary guidelines states that a high potassium diet helps counteract the effect of salt on blood pressure. They recommended an intake of 4.7g of potassium per day for adults (U.S. Department of Health and Human Services and U.S. Department, 2015). The mean daily potassium intake for Irish adults is 3,784mg/day for men and 2,945mg/day for women (IUNA, 2011). These levels are lower than current U.S. recommendations for potassium of 4,700mg/day for women (U.S. Department of Health and Human Services and U.S. Department, 2015), but higher for men than WHO recommendations of 3,510mg/day (WHO, 2012). Many salt reducing studies replace NaCl with potassium chloride. However, Potassium chloride (KCl) has been found to exert a metallic and bitter taste when used in foods as a NaCl replacement (Dötsch et al., 2009).

Potassium lactate is used as a salt replacer for low sodium foods as it possesses salt-like functionality, has strong water binding properties and is antimicrobial Shelef. (1994). However, potassium lactate has no off-flavours that are often associated with potassium-based products. Potassium lactate has been shown to be an effective salt replacer in meat products (Guàrdia, Guerrero, Gelabert, Gou, & Arnau (2008), Fulladosa, Serra, Gou, & Arnau (2009) & Choi, Jung, Jo, H. M., Nam, Choe, Rhee, & Kim (2014)). Combined effects of potassium lactate and calcium ascorbate as sodium chloride substitutes on the physicochemical and sensory characteristics of low-sodium frankfurter sausage. Meat Science, 96(1), 21-25.. Sensory characterisation and consumer acceptability of small calibre fermented sausages with 50% substitution of NaCl by mixtures of KCl and potassium lactate. Meat Science, 80(4), 1225-1230. Effects of potassium lactate and high pressure on transglutaminase restructured dry-cured hams with reduced salt content. Meat Science, 82(2), 213-218. due to its antimicrobial properties (Terrell, 1983). Therefore, the objective of this study was to determine assessors' preferences for sequential reductions in salt concentrations in optimised corned beef products and to determine if preference was affected by assessor age.

3. Materials and Methods

3.1 Reagents and chemicals

Sulphuric acid, hydrogen peroxide, boric acid, hydrochloric acid, sodium hydroxide, silver nitrate and potassium lactate were supplied by Sigma-Aldrich Ireland Ltd., Vale Road, Arklow, Wicklow, Ireland.

3.2 Sample Preparation

Beef (M. Semitendinous) samples were obtained from a local supplier (Ballyburden, Cork, Ireland). Beef was sourced from the local supplier on three separate occasions. Visible fat was trimmed from the beef and the samples were portioned to obtain a standard weight of 2.0kg. According to Fellendorf et al. 2018 a reduction of 60% salt in corned beef was accepted by assessors ($P \leq 0.05$) for flavour in sodium-reduced corned beef via the incorporation of 0.4% sodium and formulated with potassium lactate. Consequently, this formulation was included in this product process design.

To determine the effects of salt reduction on corned beef, a commercial reference level similar to corned beef sold at a retail level was established. A salt content of 2.0% was decided upon as the control sample (C). A higher level of 2.4% NaCl was utilised to gauge consumer's preference on higher salt addition. A moderately reduced salt level (1.5g, 20-25% reduction) was chosen and implemented to be in line with FSA guidelines (Food Standards Agency, 2009). A greatly reduced salt level was chosen and implemented so that levels (1.0g NaCl and 0.6g potassium lactate; 1.0g NaCl) were lower than set by the WHO guidelines

(WHO, 2010). All formulations employed were based around proximate analysis of salt content. All experimental formulations for corned beef samples are shown in Table 1. The lowest level of NaCl was added at level of 0.5%. A salt replacer was also added to one formulation; potassium lactate (Table 1). Six treatment batches were manufactured on three separate occasions (n=3). All samples were analysed for proximate compositional analysis, sensory analysis, and physical analysis. The curing solution was mixed for 3min at 3500rpm using a Silverson Axr mixer (Dartmouth, USA). A single needle (4mm diameter needle) hand injector was used (Friedr Dick GmbH & Co. KG, Deizisau, Germany) to inject the homogenised curing solution into the beef muscles until a 20% increase in weight was achieved. These samples were then placed in an OPA/PP laminate bag and vacuum packed (Fispak, Dublin, Ireland). All samples were the stored in the chill at 4°C for 24hr.

3.3 Cooking

The injected samples were cooked in a Zanussi convection oven (C. Batassi, Conegliano, Italy) with 100% steam at 85°C for 3hr. The product was cooked to an internal temperature of 73 °C. Cooking temperature was monitored using a temperature probe (Testo 110, Lenkirch, Germany). After cooking, all samples were transferred to the chill at 4°C.

3.4 Proximate Compositional Analysis

3.4.1 Protein Content

Protein was determined using the Kjeldahl method with slight modifications (Suhre FB , Corrao PA , Glover A, 1982). The digestion block was pre-heated (410°C). A well homogenised sample (0.8g) was weighed and placed in a digestion tube.

The tubes were placed in the heated digestion block. Samples were then removed from the digestion block and tubes cooled in the fume hood. Distilled water (50ml) was added to the cooled sample and the tubes were placed into the distillation unit along with 4% boric acid (50ml) with indicator. When distillation was completed the boric acid with indicator were titrated against 0.1N hydrochloric acid until the green colour reverted to the red colour. Percentage protein was calculated using a nitrogen conversion factor of 6.25. This method was in accordance with the work outlined by Tobin, O'Sullivan, Hamill, & Kerry (2013). The results recorded represented the average of six measurements (three independent batches x two samples x one reading).

3.4.2 Ash Content

Ash content of the corned beef was measured using a muffle furnace (Nabertherm GmbH, Lilienthal, Germany). The muffle furnace was preheated to 525°C. A 5g blended sample was weighted into a porcelain dish and placed in the muffle furnace for 6 hr., until the colour of the samples turned white. The samples were placed in a desiccator to cool. The dishes were weighted, and the ash content was calculated. The results recorded represent the average of six measurements (three independent batches x two samples x one reading).

3.4.3 Moisture and Fat

A total of 1.0g for each corned beef sample was homogenised. Samples were then analysed using the SMART Trac System (CEM GmnH, Kamp- Lintfort, Germany) for analysing moisture and fat (Bostian ML , Fish DL , Webb NB, 1985). Results recorded represented the average of six measurements (three independent batches x two samples x one reading).

3.4.4 Salt

Salt concentrations were measured in accordance with the methods of Fox (1963) using the potentiometric method for salt determination. Corned beef samples were homogenised thoroughly. A 2g sample was added to 100ml of dilute nitric acid solution (1.5ml conc. Nitric acid/L). The samples were then placed in a water bath at 60°C for 15min. Samples were then titrated with 0.1M $AgNO_3$ to +255mV using a potentiometer equipped with silver and reference electrodes. During titration, a magnetic stirrer was used. A blank titration was also carried out. By means of the ratio to chloride, sodium chloride concentrations were calculated in samples. The results recorded represent the average of six measurements (three independent batches x two samples x one reading).

3.4.5 Potassium lactate

Sodium lactate and sodium diacetate were analysed by blending 5g of the homogenised sample with 30ml of distilled water using a polytron for 30sec. The mixture was subsequently centrifuged (20min at 600g) and altered through Whatman no.1 filter paper into a clean 50ml disposable centrifuge tube. The sample was extracted using an ultrasonic bath. An aliquot of filtrate was subsequently filtered a second time with a 0.2µ m membrane filter and transferred to an auto injector vial. Organic acids content was determined by a HPLC (high performance liquid chromatography) method with UV (ultra violet) detection. Filtrates were analysed directly by using a high-performance liquid chromatograph (Perkin Elmer Series 200) with a flow rate of 0.6ml/min, an injection of 20µl, a 220nm detector, and a run time of 20 to 30 min

(Seman, Borger, Meyer, Hall, & Milkowski, 2002). Results recorded represent the average of six measurements (three independent batches x two samples x one reading).

2.4.6 Carbohydrates

Total carbohydrates were determined by difference: A 100g sample quantity minus the addition of protein, fat, water and ash in grams, expressed as a percentage. The results recorded represent the average of six measurements (three independent batches x two samples x one reading).

3.5 Sensory Analysis

3.5.1 Recruitment

Panellists of varying age cohorts were recruited for this study. Panellists were chosen in compliance with the following criteria; community dwelling, health status, potential allergies, swallowing difficulties, and regular consumers of corned beef. Trial subjects were recruited from University College Cork and from active retirement groups based around the Cork region to allow for an older consuming demographic within the study. Assessor cohorts were derived from various socio-economic backgrounds and were gender balanced. Sensory analysis was carried out on untrained assessors (n=256). The ages ranged from 18-85 years of age. The sample size of the various age cohorts was as follows; 18-24 (n=33), 25-34 (n=43), 35-44 (n=40), 45-54 (n=51), 65-74 (n=45) & 75+ (n=44). In accordance with the health concerns issued by the FSAI, panellists were required to fill out a disclaimer indicating that they did not have any of the following aliments: Type 1 diabetes, chronic renal insufficiency, end stage renal disease, severe heart failure and adrenal insufficiency (FSAI, 2015).

3.5.2 Sensory Evaluation

Each panellist rated the sensory qualities of the samples in triplicate on triplicate batches (each batch manufactured separately), according to the methods of the American Meat Science Association (AMSA, 2015). All samples were served cold and they were cut into 3mm thick slices. All samples were presented to assessors on a white polystyrene plate. Each sample was presented at random with corresponding codes on the plate. Panellists were asked to rinse their mouths with water in between each sample in accordance with the methods of Tobin et al (2012). The experiment was conducted in panel booths which conformed to international standards (ISO, 2007). Panellists were asked to rate the coded and order randomised samples using an ten-point continuous line scale (AMSA, 2015). The following hedonic attributes were assessed; appearance, flavour, texture, colour and overall acceptability. The following intensity attributes were examined; beef aroma, saltiness, beef flavour and off-flavour. The definitions presented to each panellist are outlined in Table 2.

3.6 Physical Analysis

3.6.1 Cooking Loss

Prior to cooking, all samples were taken out of the OPA/PP vacuum bags and weighed. After cooking the weight of the samples were recorded again. The differences in weights were recorded. Before weighing, each sample was blotted with a paper towel to remove excess moisture. Cooking loss was determined as the difference between cooked and raw weights expressed as a percentage of the raw weight. The results recorded represent the average of six measurements (three independent batches x two samples x one reading).

3.6.2 Texture Profile Analysis

After cooking, corned beef samples were cooled to room temperature (20°C) to determine textural properties using a texture profile analyser; Texture Analyser 16 TA-XT2I (Stable Micro Systems, Surrey, UK) following AMSA (2015) guidelines. Core samples were taken (12mm diameter) parallel to muscle fibre orientation. A 25kg load cell was used throughout testing. Textural factors were measured using descriptors highlighted by Bourne (1978). They included hardness (N): maximum force required for the initial sample compression, springiness (mm): the samples' ability to recover its original shape after initial compression and following the deforming force having been removed, cohesiveness (dimensionless): extent to which the sample could be deformed prior to rupture, measured by the areas under the compression portion instead of using the total area under positive force and resilience (dimensionless): the ratio between the negative force input to positive force input during the first compression. The results recorded represent the average of six measurements (three independent batches x two samples x one reading).

3.6.3 Colour

Colour was measured on cooked corned beef sliced samples. Samples were analysed at room temperature (20°C). Colour analysis was carried out using a Minolta CR400 Colour Meter (Minolta Camera Co. Osaka Japan). Lightness (L), redness (a ± red-green) and yellowness (b ± yellow-blue) were measured. The colourmeter features an 11mm – diameter aperture and D65 illuminant, calibrated by the CIE Lab colour space system using a white tile (C: y =

93.6, x = 0.3130, y = 0.3193). A CIE 19312 degrees standard observer was used. A minolta calibration plate was used to calibrate the analysis. Colour was measured by following AMSA guidelines (AMSA, 2012). Duplicate colour measurements were recorded on two samples from each experimental batch.

3.7 Statistical Analysis

A mixed model ANOVA was conducted in SPSS. The following interactions were measured: Treatment, age, age*treatment, session, batch and panellist. The fixed effects included treatments and panellist's ages. The batches, panellists and sessions were included as random effects. Tukeys HSD post hoc test was used to determine significant differences within the groups. The results can be viewed in Table 3. Data obtained from the corned beef sensory trials were analysed using ANOVA – Partial Least Squares Regression (APLSR) to process the mean data accumulated from the test subjects. Data was processed using Unscrambler software version 10.3. (CAMO ASA, Trondheim, Norway). The X-matrix was designed as different age categories and the corned beef samples. The Y – matrix involved the intensity and hedonic attributes of the design. The fixed effects were age cohorts and the random effects were sensory results and corned beef samples. Principal components i.e. PC 1 versus PC 2 are presented (Fig. 1). Regression coefficients were analysed by Jack-knifing for intensity and hedonic attributes (Tables 4 & 5) to derive significant indicators for the relationships determined in the quantitative APLSR, which is based on cross validation and stability plots.

Proximate (Table 6) and physiochemical (Table 7) compositional analysis data are presented as the mean values±standard error of the mean (SEM). One-way ANOVA was used to examine the data from proximate and physiochemical analysis. The data was subjected to descriptive analysis and tests for normality (Shapiro-Wilk test), Independence and Equality of Variances (Levene's test) were performed. The assumptions of the relevant statistical tests were satisfied in all cases. Tukey's post-hoc test was used to adjust for multiple comparisons between treatment means. All statistical analysis was carried out using the SPSS 11.0 software package for Windows (SPSS, Chicago, IL, USA).

4. Results & Discussion

4.1 Sensory Analysis

From Table 3 it can be seen that panelist's interaction significantly affected all of the hedonic and the intensity sensory descriptors. Results from the sensory evaluation of corned beef with varying salt levels and replacers are displayed in APLSR plot (Fig. 1) and the corresponding ANOVA values (*P* values of beta-coefficients), including significance and correlation factors presented in Table 4 for hedonic and Table 5 for intensity sensory assessments. The attributes of 'saltiness', 'off flavour' and 'metallic flavour' are located on the top right-hand side of the plot (Fig. 1). Liking of texture, acceptability, appearance, colour and flavour were all located on the bottom left quadrant in close proximity. Many studies have demonstrated that flavour and texture are the key sensory factors driving assessors preference for beef products (Morgan et al., 1991; Lorenzen, Neely, Miller & Tatum, 1999; Boleman et al., 1997).

The 35-44 age cohort liked corned beef samples which contained 1.0% NaCl & 0.6% Potassium lactate for the following attributes: appearance, flavour and texture ($P \leq 0.001$), ($P \leq 0.001$) and ($P \leq 0.05$), respectively (Table 4). This age group associated this sample with beef flavour ($P \leq 0.01$) and metallic flavour (Table 5). This age cohort was the only age cohort to like the 1.0% NaCl and 0.6% potassium lactate corned beef sample. Salt reduction may impact consumer subgroups differently. In a salt replacement trial conducted by

Guàrdia, Guerrero, Gelabert, Gou, & Arnau, (2008), it was concluded that a reduction of 50% NaCl in fermented sausages could be carried out successfully by substitution with 50% KCl or with a mixture of KCl/K-lactate (40:10) without changing the overall acceptability of the product, independently of gender, residence, educational level or assessor age. However, cluster results showed that there could be some groups of assessors who would accept other mixtures of KCl/K-lactate as salt substitutes (20:30 and 30:20) (Guàrdia et al., 2008). From Fig 1. the majority of corned beef samples containing potassium lactate were associated with attributes such as beef aroma, beef flavour, appearance, liking of colour, liking of flavour, acceptability and liking of texture. This finding is in accordance with the work of Fellendorf et al. (2017) (in press) who found that corned beef with a mixture of NaCl (0.40%) and Potassium lactate (0.02%) was accepted for its flavour in a consumer trial. Gelabert, Gou, Guerrero, & Arnau, (2003) conducted a salt reduction trial on fermented sausages. NaCl was reduced by the addition of potassium lactate At levels above 40%, the combination of both salt replacers negatively impacted upon the texture and flavour qualities of the product. In contrast, Fulladosa, Serra, Gou, & Arnau, (2009) found that potassium lactate did not negatively impact upon the flavour or texture of cured hams.

Corned beef samples containing 2.4% salt represented products containing the highest amount of NaCl (Table 6) of all the samples investigated. The 18-24 age group did not like this high salt sample for its appearance, flavour, texture, colour and acceptability ($P \leq 0.05$), ($P \leq 0.001$), ($P \leq 0.01$), ($P \leq 0.01$) and ($P \leq 0.001$), respectively (Table 4). This was an unexpected result as younger age groups have been found to prefer saltier foods (Wansink, Cheney, & Chan 2003). Exploring comfort food preferences across age and gender. Physiology & behavior, 79(4-5), 739-747. This age perceived the high NaCl sample negatively. The 18-24 age group also did not perceive beef flavour in this sample ($P \leq 0.01$). The 35-44 age group liked samples containing 2.4% NaCl for appearance and flavour ($P \leq 0.01$) (Table 4). NaCl is a flavour enhancer due to of its effect on different biochemical mechanisms (Albarracín, Sánchez, Grau, & Barat, 2011). The 35-44 age group did not associate the sample containing 2.4% NaCl with off-flavour or metallic flavour ($P \leq 0.05$) (Table 5). The older age cohorts did not perceive the high NaCl (2.4%) samples as positive. Taste detection and taste recognition for the five basic tastes (sweet, sour, bitter, umami & salty) and have been proven to decline as the aging process occurs (Schiffman, 1993; Schiffman, 1998; Warwick & Schiffman, 1990 & Mojet, 2003). An increased detection threshold may indicate that the elderly require the presence of more molecules for a sensation to be perceived compared to younger subjects. An increased recognition threshold indicates that a higher concentration of the tastant is needed before it can be identified correctly (Schiffman, 2008).

The control sample contained 2.0% NaCl in the final product, which is double that in samples containing 1% NaCl & 0.6% potassium lactate and the sample containing 1.0% NaCl. This sample was used as the control sample as it has the closest NaCl value to commercial corned beef samples. The 18-24 age group associated the control sample with saltiness ($P \leq 0.01$) (Table 5). This age cohort did not perceive a beef flavour with the sample possibly due to the high salt concentration. This age cohort could also identify the higher salt content sample. Many studies have demonstrated the superior sensitivity ability of younger assessors to identify flavours over older age cohorts (Schiffman, 1977; Philipsen, Clydesdale, Griffin, & Stern, 1995). Research has demonstrated that thresholds for many tastes and odours can be as much as twelve-times higher in the senior citizens compared to younger subjects (Schiffman & Warwick, 1989). The 25-34 age group did not like the control sample for appearance, flavour, texture, colour and acceptability ($P \leq 0.001$), ($P \leq 0.001$), ($P \leq 0.001$), ($P \leq 0.01$) and ($P \leq 0.001$), respectively (Table 4), whereas, the 35-44 age cohort liked the control sample for appearance, flavour and beef flavour and they did not perceive a metallic taste with the control sample (Table 5). The 75+ age group did not like the control sample for flavour

($P \leq 0.05$) (Table 4) and also disliked the high salt content. Similar findings have been found whereby older subjects preferred less salty soups than young adults (Drewnowski, Henderson, Driscoll, & Rolls, 1996). This evidence conflicts with the theory that older assessors have a preference for saltier foods. Little or no effect of age was found when the perceived saltiness of mashed potatoes was measured (Zallen, Hooks, & O'Brien, 1990). There were extremely dynamic observations noted in the sensory testing among the age cohorts for the control sample, thereby suggesting that the current commercial corned beef on the market may not appeal to all assessors. The sample most negatively perceived was the control sample, thereby suggesting that the levels of NaCl added to commercial corned beef is currently too high for assessors' acceptance, and in some incidences, beef flavour was not noted but an off-flavour was.

Corned beef samples containing 1.5% NaCl (Table 6) in the final product featured a reduction of NaCl closest to the FSA 2012/2017 guidelines (reducing NaCl levels to 1.63g/100g in corned beef). The 35-44 age group liked the appearance and flavour of the sample containing 1.5% NaCl ($P \leq 0.01$) and ($P \leq$ 0.01), respectively (Table 4). This age group did not link the sample containing 1.5% NaCl with either off-flavour ($P \leq 0.05$) or metallic flavour ($P \leq 0.01$) (Table 5). The 65-74 age group did not like samples containing 1.5% NaCl for appearance ($P \leq 0.01$) and flavour ($P \leq 0.05$) (Table 4). They did not link this sample with beef flavour ($P \leq 0.05$), but they did associate it with having a metallic flavour ($P \leq 0.01$) (Table 5). There was no metallic flavour noted in this sample by the other age cohorts. There has been many attempts to encourage people to change to more healthy diet, however, significant changes are unlikely, particularly as people increase in age according to Devine, Connors, Bisogni, & Sobal, (1998) or have already developed a preference for their own traditional foods (Laureati, Pagliarini, Calcinoni, & Bidoglio, 2006). It is therefore difficult to identify the type of policies that may work, as some researchers report changes in behaviour whilst others do not (Capacci et al., 2012). In a study examining how perceptions of food quality are explained by demographic and socio-economic features at the individual level, it was found that that women, older and more educated individuals are more interested in calories, safety and taste of food (Baiardi, Puglisi, & Scabrosetti, 2016). Thus, a reduction to 1.63% of NaCl in processed or cured meats is achievable without inducing off-flavours or metallic flavours. A reduction of 1.63% of NaCl in the present study did not negatively impact the flavour for all age cohorts, except for the 65-74 age cohort.

The corned beef sample containing 1.0% NaCl in the final product included the same NaCl as the sample containing 1.0% NaCl & 0.6% potassium lactate, as can be seen in Table 6. These samples had the closest NaCl level to the WHO salt targets (WHO, 2010) which recommends a reduction to 1.35g/100g salt in corned beef. The 18-24 age category liked the sample containing 1.0% NaCl and no potassium lactate for flavour, colour and acceptability ($P \leq 0.05$), ($P \leq 0.05$) and ($P \leq 0.01$), respectively (Table 4). The 25-34 age category liked this sample for both appearance and flavour ($P \leq 0.05$) (Table 4). They also associated this same sample as having a beef flavour ($P \leq 0.05$) (Table 5). The 35-44 age cohort linked the sample containing 1.0% NaCl for both appearance and flavour ($P \leq 0.01$) (Table 4). This age cohort did not associate this sample with having an off-flavour ($P \leq 0.01$) or a metallic flavour ($P \leq 0.05$) (Table 5). The 45-64 age group liked the flavour of this sample ($P \leq 0.05$) (Table 4), and did not perceive off-flavours with this sample ($P \leq 0.05$) (Table 5). There were no major sensory differences noted between the sample containing potassium lactate (1.0% NaCl & 0.6% potassium lactate) and that without potassium lactate (1.0% NaCl). Thus, potassium lactate may be added to corned beef without effecting sensory results, whilst increasing the health benefits (FSAI, 2015) associated with potassium. In a socio-demographic and attitudinal study examining the consumer's willingness to compromise on taste for health in functional foods, the authors found that that the gap between the acceptances of good versus the worst tasting functional foods has changed significantly from 2001 to 2004. Females and elderly were more ready to compromise on taste for health in 2001, any socio-demographic differences became redundant by 2004. Thus, the health benefits associated with functional foods emerges as the strongest positive determinant of willingness to compromise on taste (Verbeke, 2006). Consumer's attitudes towards foods are constantly changing and developing. Belief in the health benefits of functional foods is the main positive determinant of acceptance (Verbeke, 2005).

As can be seen in Fig 1., the corned beef sample containing 1.0% NaCl was associated with off-flavour and metallic flavour by the senior citizen age cohorts (65 yrs old and over). However as can be seen from Table 5, this perception was not significant. All the age cohorts examined in this study, with the exception of the 65-74 age cohort accepted the flavour attribute of the corned beef with the closest salt level to the FSA target (1.0% NaCl). Food neophobia is often common in senior citizen assessors. It is defined as the reluctance to try novel foods (Pliner & Hobden, 1992). Taste has been proven to be a more important factor in deciding assessors preference for food products in older age cohorts compared to younger ones (Kälviäinen, Roininen, & Tuorila, 2003a). One study examined the different effects of various flavour amplification on soup, Quorn® and yoghurt on preference and consumption in young and elderly subjects. Test subjects aged 60 years or more (n=20) and healthy young person's 20-30 years (n=16) were examined. The majority of the younger subjects were found to prefer the low favour soup, Quorn® and yoghurt, while the elderly subjects preferred the high favour level soup, Quorn® and yoghurt. The authors concluded that flavour amplification of food for the elderly deserves attention and regular consumption of such manipulated food products would consequently improve nutritional status (Kälviäinen, Roininen, & Tuorila, 2003).

The corned beef sample containing 0.5% salt contained the lowest NaCl formulation in this trial. The 35-44 age group liked this sample for appearance, flavour and texture ($P \leq 0.05$), ($P \leq 0.01$) ($P \leq 0.05$), respectively (Table 4). They also associated this sample with having a beef aroma ($P \leq 0.05$) but did not associate it with having an off-flavour ($P \leq 0.01$) (Table 5). The 45-64 age group did not associate sample (0.5% NaCl) with off-flavour ($P \leq 0.05$). This sample was perceived differently among the various age cohorts. Fig. 1. illustrates how the sample is spread out over three quadrants of the APLSR plot. The younger age cohorts: 18-24, 25-34 and 35-44 liked this sample (as can be seen on the left-hand side of the diagram). In contrast, the 45-64, 65-74 and the 75+ age categories disliked the samples (as can be seen on the right-hand side of the diagram) by describing the samples as being salty, possessing off-flavour and possessing metallic flavour. Previous studies have found that salt taste, juiciness and texture were the sensory parameters most affected by NaCl reduction (Aaslyng, Vestergaard, & Koch, 2014). As this sample featured a lower NaCl level recommended by the WHO and FSA salt targets, it illustrates the possibility of reducing these targets further, particularly for younger consumers. Overall the most dynamic sensory results were observed for the sample containing the highest NaCl level (2.4 % NaCl) and the sample containing the lowest NaCl level (0.5 % NaCl). The youngest age cohort (18-24) disliked the sample containing the most salt whereas the senior citizen age cohorts did not notice any difference in that sample compared to the others. Varying sensory preferences were noted among assessors of different age cohorts throughout this study.

4.2 Proximal Compositional Analysis

The Proximal compositional analysis results obtained in this study are presented in Table 6.

The samples ranged in fat content from (2.5-4.4%) these values are much lower than those recorded in other salted beef products, as the fat was initially removed to standardise the beef pieces used in this study. The UK Mc Cance and Widdowson database recorded a fat content of 7.0% in its lean beef samples (Mc Cance and Widdowson, 2005). Moisture content varied significantly among samples. The corned beef sample containing 1.0% NaCl & 0.6% potassium lactate and that containing 1.0% NaCl had the same NaCl content and it was the same in terms of moisture content.

Even though the results were non-significant, the moisture content of corned beef containing 1.0% NaCl & 0.6% potassium lactate was lower than that of the meat sample containing only 1.0% NaCl. In a previous salt replacement study, it was found that potassium lactate reduced the moisture content (P<0.05) of products, thereby increasing the preservative effect of potassium lactate (Choi & Chin, 2003). Therefore, this corresponds well with a mechanistic explanation of how the addition of potassium lactate reduces the growth of microbes in meat products. There were no significant differences observed in carbohydrate values. This result was expected as no extra carbohydrates were added to the meat at any stage of production. NaCl values were not significantly different in corned beef samples containing 1.0% NaCl & 0.6% potassium lactate and 1.0% NaCl. Both meat samples had 1.0% NaCl. The remainder of the samples differed in their NaCl content significantly. As expected, potassium lactate values did not differ, apart from that meat sample containing KI (1.0 NaCl & 0.6 potassium lactate). Corned beef samples containing 1.0% NaCl & 0.6% K and 1.0% NaCl did not differ in terms of ash content.

4.3 Physiochemical Analysis

The corned beef samples containing 1.0% NaCl & 0.6% potassium lactate and 1.0% NaCl with no added potassium lactate both contained 1.0% NaCl when physiochemical analysis was carried out (Table 6). The beef sample which contained 1.0% NaCl & 0.6% potassium lactate did contain potassium lactate, whereas sample (1.0% NaCl) did not contain any as expected. Regarding sensory analysis, no age group associated any of these samples with negative attributes; off-flavour and metallic flavour. However, regarding physiochemical analysis (Table 7) corned beef samples containing 1.0% NaCl & 0.6% potassium lactate was significantly lighter in colour than samples containing 1.0% NaCl. The corned beef samples containing 1.0% NaCl & 0.6% potassium lactate had significantly lower values for a* and b* than samples containing only 1.0% NaCl. The addition of potassium lactate affected the colour of the corned beef. The sensory consumer test did not record any differences in colour between the two samples. No significant differences were noted between the corned beef samples which contained 1.0% NaCl & 0.6% potassium lactate and the sample containing 1.0% NaCl when cohesiveness and resilience were measured. In a salt reduction study NaCl in fermented sausages was substituted using levels higher than 30% of potassium lactate, potassium chloride, and glycine. A loss of cohesiveness was noted following sensory analysis in the NaCl substituted samples (Gou, Guerrero, Gelabert, & Arnau, 1996). This current study did not utilise a complete salt replacer this may account for the lack of cohesiveness differences observed from TPA analysis. The cooking loss result of the sample containing potassium lactate was lower than the other samples not containing potassium lactate. Due to its hygroscopisity, potassium lactate has a positive effect on a products water holding capacity, which may result in less purge, a higher cook yield and an improved texture for cooked product (Shelef, 1994).

5. Conclusion

The tailoring of food formulation to cater for different sensory preferences amongst different age groups presents a potential untapped market for the meat industry. Variations in taste, texture and mouth feel may be produced by adding various salt replacers to cured meats which cater for different sensory preferences by different consuming age cohorts. Potassium lactate may be added to meats as a salt replacer without influencing the sensory qualities for certain age groups. This study adds to the already existing evidence that age-related differences in sensory acceptance of foods exists.

The reformulation of common foods is a positive step in achieving certain public health interventions. However, it is essential that these foods are accepted by the consumer and meets their sensory expectations when reformulating them. Not all food products need the high level of salt that is added during processing to gain consumer acceptability, as demonstrated in this study. This research provides evidence for the acceptance of assessors for the FSA and WHO salt targets in processed foods in certain age cohorts. The samples that featured a NaCl reduction level like the FSA and the WHO NaCl reduction recommendations were positively perceived among all age cohorts, but not within the senior citizen age bracket (≥64 yrs. old). This study demonstrates an acceptance for a salt level as low as 0.5% NaCl in corned beef for those consumers aged under 45 years of age.

The youngest age cohort (18-24) disliked corned beef samples containing the highest level of NaCl, whereas the oldest age cohorts (≥ 65 yrs. old) did not notice any significant difference between samples. No differences were observed in the ≥ 65 yrs. old age cohort between the sample containing potassium lactate and that not containing potassium lactate. Thus, it may be possible to manipulate processed meats that contain potassium lactate without influencing the sensory perception of the senior age cohorts, while incurring added health benefits. Food tailored to the elderly consumer is a valuable approach to targeting malnutrition due to sensory perception decline in this age cohort.

Assessors of varying age groups have differing preferences for certain NaCl levels and salt replacers. As previously stated assessors consume varying levels of salt according to their age cohort and gender. The meat industry could explore various possibilities, including the control of the raw and processed materials to produce bespoke design foods reformulated to cater for public health needs. The onus is on the food industry to facilitate convenient healthier food products with an emphasis on sensory acceptance for its different consumer segments.

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Table 1: Formulation table of curing solution

Attribute	Definition	Scale

Sample	NaCl(g)/1L curing solution ***	KNO_2/1L curing solution (g/1L)	K (lactate(g))/1L curing solution
1.0 NaCl & 0.6Kl *	60.96	0.11	40.32
C**	152.4	0.11	0.00
2.4 NaCl	121.92	0.11	0.00
1.5 NaCl	91.44	0.11	0.00
1.0 NaCl	60.96	0.11	0.00
0.5 NaCl	30.48	0.11	0.00

* 1.0 NaCl & 0.6 Kl (expressed as %) = Sample containing salt replacers; Kl & Glycine

** C = Control sample

*** All samples expressed in grams per 1L of curing solution

Kl = Potassium Lactate

Table 2: Hedonic and intensity sensory

Hedonic		
Appearance	Liking of appearance	0 = extremely dislike 10= extremely like
Flavour	Liking of flavour	0 = extremely dislike 10= extremely like
Texture	Liking of texture	0 = extremely dislike 10= extremely like
Colour	Liking of colour	0 = extremely dislike 10= extremely like
Acceptability	Acceptability of sample	0 = extremely dislike 10= extremely like
Intensity		
Beef Flavour	Taste sensation typically associated with beef	0=none 10=extreme
Saltiness	Taste sensation of which salt is typical	0=none 10=extreme
Beef Aroma	Orthonasal sensation typically associated with beef	0=none 10=extreme
Off-flavour	Off-flavour (rancid) flavour not typically associated with corned beef	0=none 10=extreme
Metallic Flavour	A taste remaining in the mouth of coins/metal after eating	0=none 10=extreme

attributes

Table 3: Significance of relationships between sensory descriptors, fixed (treatment, age and treatment*age interaction) and random factors (session, batch and panellist)

	Hedonic					Intensity				
Sensory	**Appearance**	**Flavour**	**Texture**	**Colour**	**Acceptability**	**Beef aroma**	**Saltiness**	**Beef flavour**	**Off-flavour**	**Metallic flavour**
Treatment	0.922^{ns}	0.446	0.961 ^{ns}	0.974 ^{ns}	0.908 ^{ns}	0.465 ^{ns}	0.865 ^{ns}	0.764 ^{ns}	0.935 ^{ns}	0.367 ^{ns}
Age	0.513 ^{ns}	0.000***	0.316 ^{ns}	0.704 ^{ns}	0.000***	0.974 ^{ns}	0.049*	0.178 ^{ns}	0.017*	0.000***
Age * Treatment	0.901 ^{ns}	0.903 ^{ns}	0.879 ^{ns}	0.898 ^{ns}	0.982 ^{ns}	0.948 ^{ns}	0.009**	0.857 ^{ns}	0.613 ^{ns}	0.048*
Session	0.092 ^{ns}	0.007**	0.029*	0.022*	0.051*	0.017*	0.000***	0.140 ^{ns}	0.139 ^{ns}	0.379 ^{ns}
Batch	0.092 ^{ns}	0.007**	0.029*	0.022*	0.051*	0.017*	0.000***	0.140 ^{ns}	0.139 ^{ns}	0.379 ^{ns}
Panellist	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

P values of regression coefficients; * = ($P \leq 0.05$), ** = ($P \leq 0.01$), *** = ($P \leq 0.001$) ^{ns} = non-significant

Kl = Potassium Lactate

Table 4: ANOVA-Partial Least Squares regression illustrating the samples and age cohort's vs the hedonic sensory attributes

Sample	Age Cohort	Appearance	Flavour	Texture	Colour	Acceptability
[1] 1 NaCl & 0.6 Kl						
	(18-24)	[2]-0.362 [3] ^{ns}[4]	-0.436 ^{ns}	-0.444 ^{ns}	-0.584 ^{ns}	-0.655 ^{ns}
	(25-34)	-0.439 ^{ns}	-0.326 ^{ns}	-0.332 ^{ns}	-0.447 ^{ns}	-0.335 ^{ns}
	(35-44)	0.000 ***	0.000 ***	0.032 *	0.079 ^{ns}	0.088 ^{ns}
	(45-64)	0.120 ^{ns}	0.100 ^{ns}	0.225 ^{ns}	0.298 ^{ns}	0.342 ^{ns}
	(65-74)	-0.101 ^{ns}	-0.127 ^{ns}	-0.265 ^{ns}	-0.346 ^{ns}	-0.345 ^{ns}
	(75+)	0.186 ^{ns}	0.215 ^{ns}	0.321 ^{ns}	0.387 ^{ns}	0.401 ^{ns}
2.0 NaCl						
	(18-24)	-0.032 *	-0.000 ***	-0.005 **	-0.007 **	-0.000 ***
	(25-34)	0.648 ^{ns}	0.321 ^{ns}	0.624 ^{ns}	0.699 ^{ns}	0.465 ^{ns}
	(35-44)	0.007 **	0.007 **	0.092 ^{ns}	0.156 ^{ns}	0.178 ^{ns}
	(45-64)	0.080 ^{ns}	0.104 ^{ns}	0.232 ^{ns}	0.290 ^{ns}	0.325 ^{ns}
	(65-74)	-0.588 ^{ns}	-0.680 ^{ns}	-0.607 ^{ns}	-0.621 ^{ns}	-0.659 ^{ns}
	(75+)	0.101 ^{ns}	0.085 ^{ns}	0.226 ^{ns}	0.300 ^{ns}	0.329 ^{ns}
C						
	(18-24)	-0.000 ***	-0.000 ***	-0.080 ^{ns}	-0.039 *	-0.003 **
	(25-34)	-0.000 ***	-0.000 ***	-0.001 ***	-0.011 **	-0.000 ***
	(35-44)	0.002 **	0.009 **	0.157 ^{ns}	0.264 ^{ns}	0.213 ^{ns}
	(45-64)	0.086 ^{ns}	0.138 ^{ns}	0.307 ^{ns}	0.401 ^{ns}	0.381 ^{ns}
	(65-74)	-0.325 ^{ns}	-0.233 ^{ns}	-0.405 ^{ns}	-0.386 ^{ns}	-0.291 ^{ns}
	(75+)	-0.131 ^{ns}	-0.049 *	-0.138 ^{ns}	-0.114 ^{ns}	-0.089 ^{ns}
1.5 NaCl						
	(18-24)	0.823 ^{ns}	0.626 ^{ns}	0.623 ^{ns}	0.688 ^{ns}	0.233 ^{ns}
	(25-34)	0.606 ^{ns}	0.801 ^{ns}	0.716 ^{ns}	0.779 ^{ns}	0.849 ^{ns}
	(35-44)	0.005 **	0.008 **	0.118 ^{ns}	0.190 ^{ns}	0.191 ^{ns}
	(45-64)	0.127 ^{ns}	0.073 ^{ns}	0.162 ^{ns}	0.240 ^{ns}	0.307 ^{ns}
	(65-74)	-0.011 **	-0.025 *	-0.189 ^{ns}	-0.283 ^{ns}	-0.290 ^{ns}
	(75+)	0.206 ^{ns}	0.289 ^{ns}	0.383 ^{ns}	0.457 ^{ns}	0.500 ^{ns}
1.0 NaCl						
	(18-24)	0.332 ^{ns}	0.024 *	0.155 ^{ns}	0.026 *	0.007 **
	(25-34)	0.021 *	0.040 *	0.162 ^{ns}	0.236 ^{ns}	0.232 ^{ns}
	(35-44)	0.015 **	0.005 **	0.078 ^{ns}	0.131 ^{ns}	0.150 ^{ns}
	(45-64)	0.063 ^{ns}	0.021 *	0.101 ^{ns}	0.158 ^{ns}	0.194 ^{ns}
	(65-74)	-0.682 ^{ns}	-0.648 ^{ns}	-0.673 ^{ns}	-0.647 ^{ns}	-0.612 ^{ns}
	(75+)	0.250 ^{ns}	0.280 ^{ns}	0.375 ^{ns}	0.437 ^{ns}	0.479 ^{ns}
0.5 NaCl						
	(18-24)	0.668 ^{ns}	0.064 ^{ns}	0.850 ^{ns}	0.682 ^{ns}	0.334 ^{ns}
	(25-34)	0.726 ^{ns}	0.367 ^{ns}	0.651 ^{ns}	0.590 ^{ns}	0.268 ^{ns}
	(35-44)	0.029 *	0.002 **	0.053*	0.094 ^{ns}	0.119 ^{ns}
	(45-64)	0.092 ^{ns}	0.025 ^{ns}	0.103 ^{ns}	0.162 ^{ns}	0.210 ^{ns}
	(65-74)	-0.647 ^{ns}	-0.532 ^{ns}	-0.686 ^{ns}	-0.586 ^{ns}	-0.503 ^{ns}
	(75+)	-0.804 ^{ns}	-0.997 ^{ns}	-0.824 ^{ns}	-0.893 ^{ns}	-0.972 ^{ns}

[1] Sample and age group, [2] the sign dictates whether the correlation is positively or negatively correlated, [3] estimated regression coefficients from ANOVA-Partial Least Squares Regression (APLSR) (ANOVA values), [4] *P* values: ns= not significant; $^{*}P \leq 0.05$, $^{**}P \leq 0.01$, $^{***}P \leq 0.001$. Kl = Potassium Lactate

Table 5: ANOVA-Partial Least Squares regression illustrating the samples and age cohort's vs the intensity sensory attributes

Sample	Age Cohort	Beef Aroma	Saltiness	Beef Flavour	Off Flavour	Metallic Flavour
[1] 1 NaCl & 0.6 Kl	(18-24)	-[2] 0.321[3] ns[4]	-0.322 ns	-0.359 ns	-0.683 ns	-0.669 ns
	(25-34)	-0.929 ns	-0.879 ns	-0.653 ns	0.574 ns	0.653 *
	(35-44)	0.077 ns	-0.516 ns	0.012 **	-0.002 **	0.007 **
	(45-64)	0.207 ns	-0.677 ns	0.168 ns	-0.130 ns	0.164 *
	(65-74)	-0.372 ns	0.652 ns	-0.143 ns	0.218 ns	-0.085 *
	(75+)	0.373 ns	-0.653 ns	0.209 ns	-0.266 ns	-0.187 *
2.0 NaCl	(18-24)	-0.205 ns	0.395 ns	-0.006 **	0.289 ns	0.559 ns
	(25-34)	0.570 ns	-0.545 ns	0.528 ns	-0.652 ns	-0.838 ns
	(35-44)	0.121 ns	-0.589 ns	0.023 *	-0.026 *	-0.025 *
	(45-64)	0.250 ns	-0.670 ns	0.136 ns	-0.150 ns	-0.125 ns
	(65-74)	-0.497 ns	0.987 ns	-0.341 ns	0.745 ns	0.725 ns
	(75+)	0.262 ns	-0.641 ns	0.196 ns	-0.113 ns	-0.120 ns
C	(18-24)	-0.072 ns	0.003 **	-0.000 ***	0.063 ns	0.067 ns
	(25-34)	-0.579 ns	0.136 ns	-0.062 ns	0.003 **	0.093 ns
	(35-44)	0.412 ns	-0.530 ns	0.014 **	-0.170 ns	-0.003 **
	(45-64)	0.472 ns	-0.639 ns	0.127 ns	-0.306 ns	-0.098 ns
	(65-74)	-0.506 ns	0.187 ns	-0.307 ns	0.434 ns	0.467 ns
	(75+)	-0.166 ns	0.312 ns	-0.181 ns	0.094 ns	0.248 ns
1.5 NaCl	(18-24)	0.967 ns	-0.881 ns	0.669 ns	-0.947 ns	-0.936 ns
	(25-34)	0.704 ns	-0.927 ns	0.426 ns	-0.789 ns	-0.663 ns
	(35-44)	0.220 ns	-0.559 ns	0.030 *	-0.041 *	-0.006 **
	(45-64)	0.126 ns	-0.735 ns	0.169 ns	-0.081 ns	-0.215 ns
	(65-74)	-0.298 ns	0.628 ns	-0.047 *	0.113 ns	0.007 **
	(75+)	0.382 ns	-0.738 ns	0.197 ns	-0.323 ns	-0.193 ns
1.0 NaCl	(18-24)	0.371 ns	-0.439 ns	0.123 ns	-0.568 ns	-0.959 ns
	(25-34)	0.244 ns	-0.546 ns	0.042 *	-0.122 ns	-0.043 *
	(35-44)	0.105 ns	-0.567 ns	0.060 ns	-0.010 **	-0.043 *
	(45-64)	0.100 ns	-0.633 ns	0.127 ns	-0.026 *	-0.133 ns
	(65-74)	-0.664 ns	0.802 ns	-0.537 ns	0.773 ns	0.830 ns
	(75+)	0.375 ns	-0.703 ns	0.328 ns	-0.269 ns	-0.223 ns
0.5 NaCl	(18-24)	0.993 ns	-0.337 ns	0.682 ns	-0.916 ns	-0.476 ns
	(25-34)	0.869 ns	-0.521 ns	0.848 ns	-0.722 ns	-0.856 ns
	(35-44)	0.052*	-0.562 ns	0.099 ns	-0.003 **	-0.094 ns
	(45-64)	0.083 ns	-0.648 ns	0.174 ns	-0.027 *	-0.187 ns
	(65-74)	-0.577 ns	0.366 ns	-0.491 ns	0.689 ns	0.799 ns
	(75+)	-0.705 ns	0.931 ns	-0.823 ns	0.761 ns	0.636 ns

[1] Sample and age group, [2] the sign dictates whether the correlation is positively or negatively correlated, [3] estimated regression coefficients from ANOVA-Partial Least Squares Regression (APLSR) (ANOVA values), [4] P values: ns = not significant; $^{*}P \le 0.05$, $^{**}P \le 0.01$, $^{***}P \le 0.001$. Kl = Potassium Lactate

Table 6: Proximal Compositional Analysis Values for Corned Beef

Sample	Fat (%)	Ash (%)	Moisture (%)	Protein (%)	Carbohydrates (%)	NaCl (%)	Kl (%)
1 NaCl & 0.6 Kl*	3.6 ± 0.00[a]	1.9 ± 0.03[d]	63.5 ± 0.18[ab]	29.0 ± 0.01[a]	1.6 ± 0.18[a]	1.0 ± 0.00[b]	0.6 ± 0.00[a]
C**	4.4 ± 0.01[b]	2.9 ± 0.00 [a]	59.9 ± 0.99 [a]	29.7 ± 0.13[b]	3.1 ± 0.99[a]	2.4 ± 0.05[e]	0.0 ± 0.00[b]
2.0 NaCl	4.1 ± 0.02[c]	2.8 ± 0.00[f]	60.3 ± 0.49[a]	30.0 ± 0.01[a]	2.9 ± 0.49[a]	2.0 ± 0.00[d]	0.0 ± 0.00[b]
1.5 NaCl	2.9 ± 0.03[d]	2.2 ± 0.02[e]	61.9 ± 1.57[ab]	30.1 ± 0.06[a]	3.6 ± 1.57[a]	1.5 ± 0.00[c]	0.0 ± 0.00[b]
1.0 NaCl	2.5 ± 0.01[e]	1.7 ± 0.00[c]	62.3 ± 0.18[ab]	31.1 ± 0.01[a]	0.7 ± 0.18[a]	1.0 ± 0.00[b]	0.0 ± 0.00[b]
0.5 NaCl	3.0± 0.00[f]	1.1 ± 0.01[b]	64.15 ± 0.31[b]	29.8 ± 0.01[a]	0.6 ± 0.31[a]	0.5 ± 0.00[a]	0.0 ± 0.00[b]

[abcdef] Mean values (± standard error of the mean) in the same column bearing different superscripts are significantly different, $P \leq 0.05$

* 1.0 NaCl & 0.6 Kl (expressed as %) = Sample containing salt replacers; Kl & Glycine (Kl = Potassium Lactate)

** C = Control sample

Table 7: Physiochemical compositional analysis values for corned beef

Sample	Cooking Loss (%)	l	a	b	Hardness (N)	Springiness (mm)	Cohesiveness (na) ♦	Resilience (na) ♦
1 NaCl & 0.6 Kl*	37.2 ± 0.01^{a}	60.6 ± 0.01^{a}	16.3 ± 0.00^{c}	10.1 ± 0.00^{a}	24.6 ± 0.01^{bc}	0.8 ± 0.01^{b}	0.5 ± 0.01^{bc}	0.2 ± 0.00^{b}
2.0 NaCl	38.3 ± 0.00^{b}	63.2 ± 0.00^{b}	16.3 ± 0.06^{b}	9.9 ± 0.01^{b}	22.8 ± 0.01^{a}	0.8 ± 0.01^{b}	0.5 ± 0.01^{c}	0.2 ± 0.00^{bc}
C**	40.4 ± 0.01^{e}	58.5 ± 0.00^{c}	16.9 ± 0.01^{b}	13.2 ± 0.00^{c}	26.5 ± 0.00^{abc}	0.7 ± 0.00^{ab}	0.5 ± 0.01^{bc}	0.2 ± 0.00^{bc}
1.5 NaCl	39.9 ± 0.01^{c}	58.4 ± 0.00^{d}	18.3 ± 0.00^{c}	12.4 ± 0.00^{d}	24.3 ± 0.00^{ab}	0.7 ± 0.02^{ab}	0.4 ± 0.00^{a}	0.2 ± 0.00^{a}
1.0 NaCl	40.3 ± 0.00^{d}	57.2 ± 0.01^{e}	17.9 ± 0.00^{a}	11.9 ± 0.00^{e}	24.2 ± 0.00^{a}	0.7 ± 0.00^{a}	0.4 ± 0.00^{ab}	0.2 ± 0.00^{b}
0.5 NaCl	40.4 ± 0.02^{e}	56.7 ± 0.00^{f}	17.7 ± 0.01^{c}	10.8 ± 0.00^{f}	24.3 ± 0.01^{c}	0.8 ± 0.09^{b}	0.5 ± 0.01^{bc}	0.2 ± 0.00^{c}

^{abc} Mean values (± standard error of the mean) in the same column bearing different superscripts are significantly different, $P \leq 0.05$

♦ (n/a) Cohesiveness & resilience measurement is dimensionless

* 1.0 NaCl & 0.6 Kl (expressed as %) = Sample containing salt replacers; Kl & Glycine

** C = Control sample

Kl = Potassium Lactate

An overview of the loadings of the X and Y variables for the first two PCs for the individual treatments and age categories V's hedonic and intensity attributes ◆

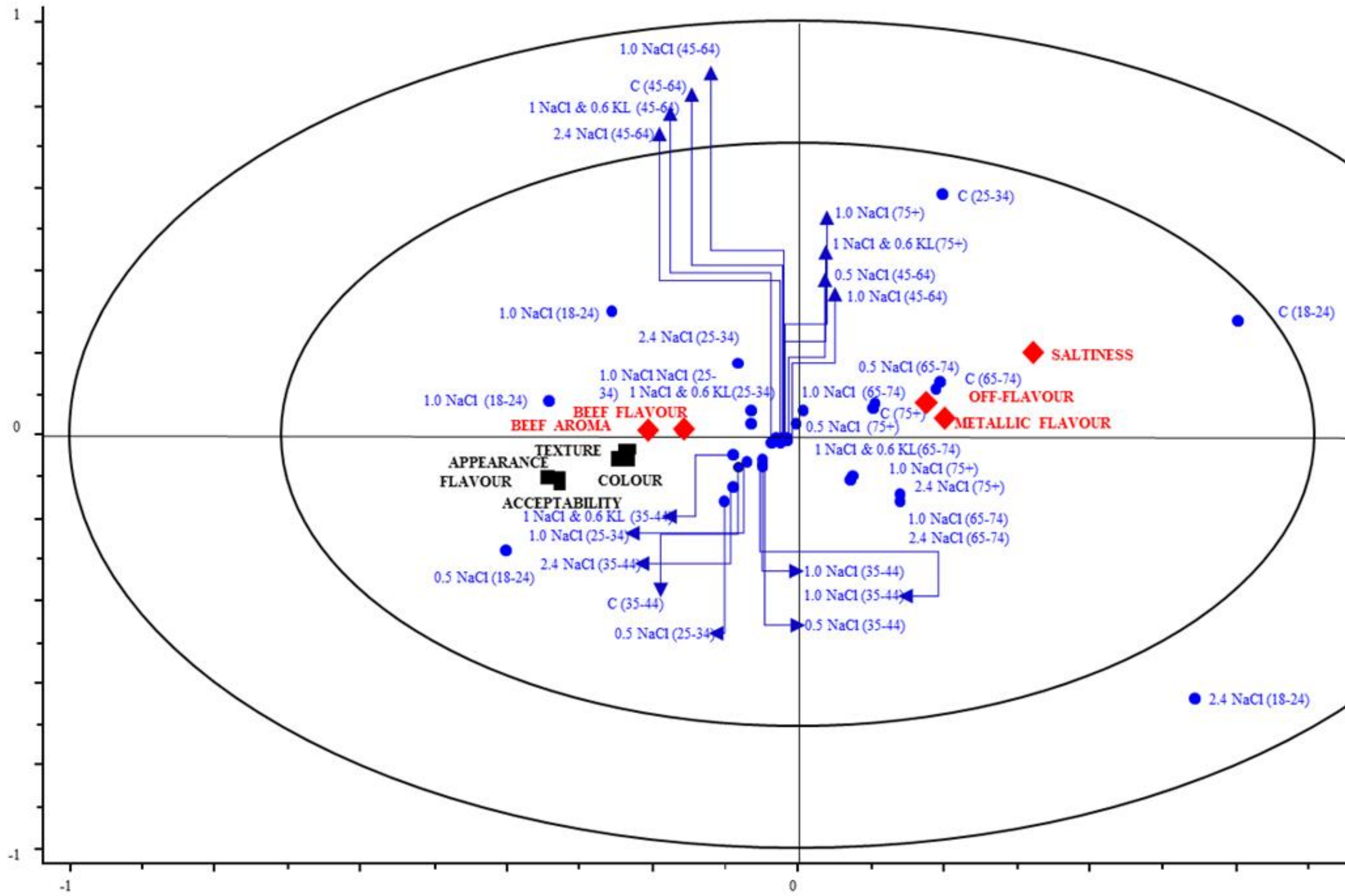

Figure 1: ANOVA - partial least squares regression (APLSR) correlation loading plot for each individual

treatment, age category and sensory descriptor and intensity rating (PC1 Vs PC2)